Fishery Data Series No. 13-61

Stock Assessment and Biological Characteristics of Burbot in Fielding Lake During 2008

by

James F. Parker

December 2013

Alaska Department of Fish and Game **Divisions of Sport Fish and Commercial Fisheries**

Symbols and Abbreviations

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Weights and measures (metric)

centimeter	cm
deciliter	dL
gram	g
hectare	ha
kilogram	kg
kilometer	km
liter	L
meter	m
milliliter	mL
millimeter	mm

Weights and measures (English)

cubic feet per second	ft^3/s
foot	ft
gallon	gal
inch	in
mile	mi
nautical mile	nmi
ounce	oz
pound	lb
quart	qt
yard	yd

Time and temperature

day	d
degrees Celsius	°C
degrees Fahrenheit	°F
degrees kelvin	K
hour	h
minute	min
second	s

Physics and chemistry

all atomic symbols	
alternating current	AC
ampere	A
calorie	cal
direct current	DC
hertz	Hz
horsepower	hp
hydrogen ion activity (negative log of)	pH
parts per million	ppm
parts per thousand	ppt, ‰
volts	V
watts	W

General

Alaska Administrative Code	AAC
all commonly accepted abbreviations	e.g., Mr., Mrs., AM, PM, etc.
all commonly accepted professional titles	e.g., Dr., Ph.D., R.N., etc.
at	@
compass directions:	
east	E
north	N
south	S
west	W
copyright	©
corporate suffixes:	
Company	Co.
Corporation	Corp.
Incorporated	Inc.
Limited	Ltd.
District of Columbia	D.C.
et alii (and others)	et al.
et cetera (and so forth)	etc.
exempli gratia (for example)	e.g.
Federal Information Code	FIC
id est (that is)	i.e.
latitude or longitude	lat or long
monetary symbols (U.S.)	$, ¢
months (tables and figures): first three letters	Jan,...,Dec
registered trademark	®
trademark	™
United States (adjective)	U.S.
United States of America (noun)	USA
U.S.C.	United States Code
U.S. state	use two-letter abbreviations (e.g., AK, WA)

Mathematics, statistics

all standard mathematical signs, symbols and abbreviations	
alternate hypothesis	H_A
base of natural logarithm	*e*
catch per unit effort	CPUE
coefficient of variation	CV
common test statistics	(F, t, χ^2, etc.)
confidence interval	CI
correlation coefficient (multiple)	R
correlation coefficient (simple)	r
covariance	cov
degree (angular)	°
degrees of freedom	df
expected value	*E*
greater than	>
greater than or equal to	≥
harvest per unit effort	HPUE
less than	<
less than or equal to	≤
logarithm (natural)	ln
logarithm (base 10)	log
logarithm (specify base)	$log_{2,}$ etc.
minute (angular)	'
not significant	NS
null hypothesis	H_O
percent	%
probability	P
probability of a type I error (rejection of the null hypothesis when true)	α
probability of a type II error (acceptance of the null hypothesis when false)	β
second (angular)	"
standard deviation	SD
standard error	SE
variance	
population	Var
sample	var

FISHERY DATA SERIES NO. 13-61

STOCK ASSESSMENT AND BIOLOGICAL CHARACTERISTICS OF BURBOT IN FIELDING LAKE DURING 2008

by
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ABSTRACT

In 2008, abundance of fully recruited (≥450 mm TL) burbot *Lota lota* was estimated in Fielding Lake using a two-sample mark-recapture experiment. Burbot were captured in baited hoop traps that were fished for 48 h and set systematically along defined transects. The first event occurred 16–21 June and the second during 8–13 September, 2008. Estimated abundance of burbot ≥450 mm TL was 894 fish (SE = 90). Estimated density of fully recruited burbot was 1.66 fish per hectare. For the first event, estimated mean CPUE per 48-h set of fully and partially (300-449 mm TL) recruited burbot in Fielding Lake was 1.30 (SE = 0.15) and 0.45 (SE = 0.08), respectively. For the second event the estimated mean CPUE per 48-h set of fully and partially recruited burbot in Fielding Lake was 0.65 (SE = 0.09) and 0.68 (SE = 0.11), respectively. Estimated abundance of burbot in Fielding Lake in 2008 was nearly twice as large as estimated abundance in 1985, and it appears that the population has recovered from the high levels of exploitation that occurred in the early 1980s. It is likely that the current sport fishing regulations in Fielding Lake will ensure that annual exploitation rates do not exceed 10%.

Key words: burbot, *Lota lota*, Fielding Lake, abundance, stock assessment, hoop traps, mean length, catch per unit effort, mark-recapture experiment

INTRODUCTION

From 1981 to 1984, the sport fishery for burbot *Lota lota* Fielding Lake (Figure 1) experienced a brief but intense period of overfishing. During this time, harvests of burbot in Fielding Lake averaged 330 fish per year (Table 1). These large harvests resulted in low abundance of the adult population by 1987 (Table 1; Parker 2001). Abundance declined again not only in 1992 but also in 1996 despite the restrictive regulations and fishing closure instituted during 1994–2001 when little to no sport harvest occurred (Parker 2001). In 1998 and 1999, increases in the burbot population allowed the Alaska Department of Fish and Game to propose regulations to reopen the fishery. In January 2001, the Alaska Board of Fisheries approved a regulation that allows a daily bag and possession limit of one burbot, prohibits the use of setlines, allows only single hooks to be used, and closes the fishery during the month of September. In 2007, the Board of Fisheries amended the regulation to add a no-bait restriction for Fielding Lake as an attempt to conserve the lake trout *Salvelinus namaycush* population. The unintended effect of this regulation is that anglers have greater difficultly catching burbot. The purpose of this study was to understand the current status of the burbot population in Fielding Lake that was last assessed in 1999.

The objectives of the study in 2008 were:

1. estimate the abundance of burbot ≥450 mm TL in Fielding Lake, such that the estimate was within 30% of the actual value 90% of the time; and
2. estimate mean catch-per-unit effort (CPUE) of partially recruited burbot (≤450 mm TL) and fully recruited burbot (≥450 mm TL) in Fielding Lake during each sampling event such that each estimate was within ±50% of its asymptotic value 90% of the time.

STUDY AREA

Fielding Lake (63°10' N, 145° 42' W) is accessible to fishermen by road from the Richardson Highway (Figures 1 and 2). The surface area of the lake is 538 ha, the maximum depth is 24 m, and the elevation of the lake is 906 m. Three inlet streams feed the lake and one outlet stream located on the north end drains the lake. The lake begins to freeze by the middle of October and breakup occurs from 15 June to 1 July. Campground and boat launch facilities are located near the outlet of the lake and several recreational cabins are located along the eastern shore. In addition to burbot, Fielding Lake contains Arctic grayling *Thymallus arcticus*, lake trout, and round whitefish *Prosopium cylindraceum*.

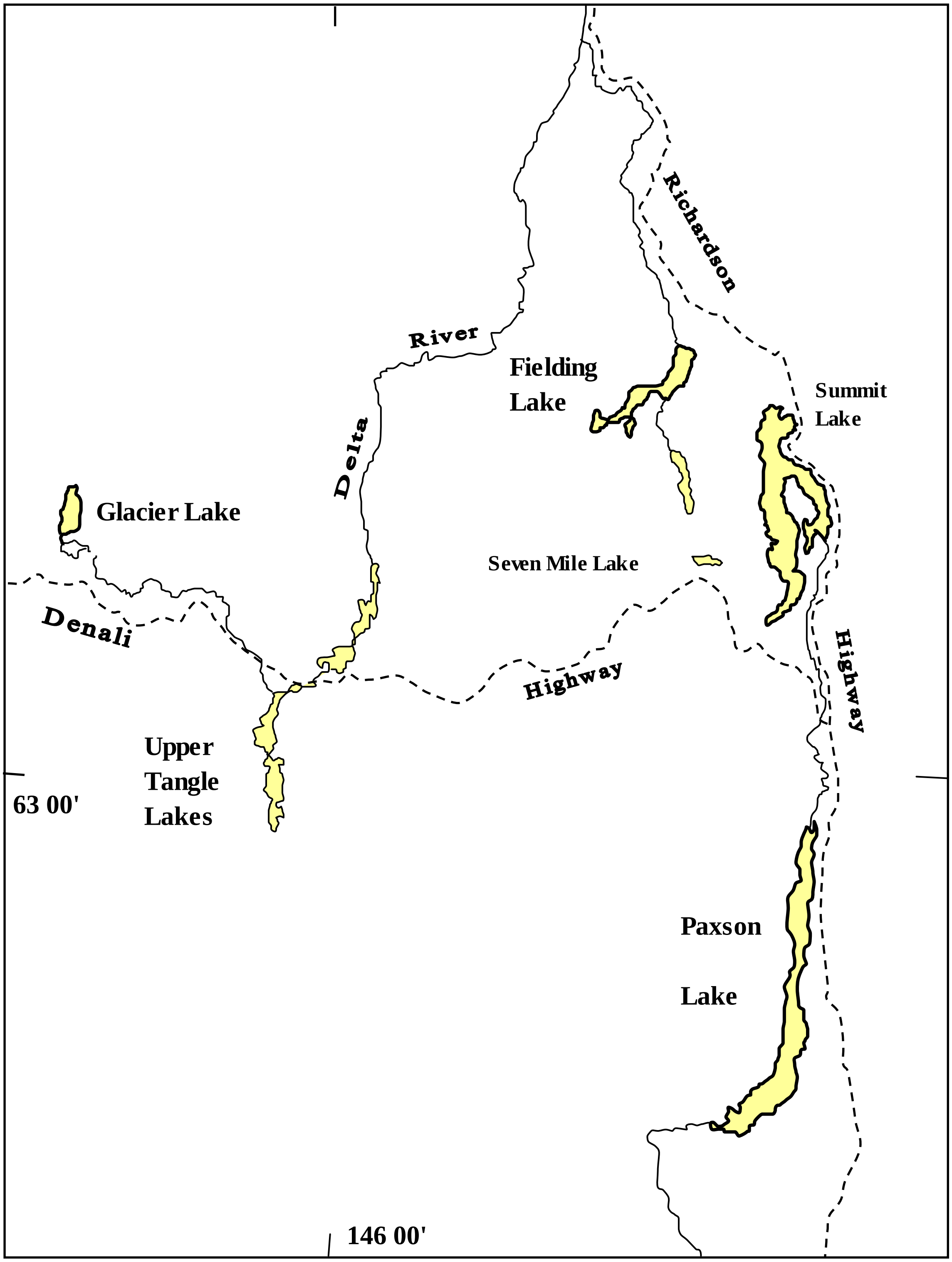

Figure 1.–Location of Fielding Lake.

Table 1.–Fishing effort, harvest, catch, abundance and exploitation rate of fully recruited burbot (≥450 mm TL) at Fielding Lake from 1981–2007.

Year	Effort[a] (Angler Days)	Harvest[a]	Catch[a]	Abundance	Exploitation Rate
1981	1,369	249			
1982	2,764	365			
1983	1,737	367			
1984	871	0			
1985	1,023	0		325	0.0%
1986	1,682	32		334	9.6%
1987	1,032	12		234	5.1%
1988	1,728	36		426	8.5%
1989	1,664	0		581	0.0%
1990	1,255	0	0	698	0.0%
1991	1,572	0	0	617	0.0%
1992	1,910	51	51	347	14.7%
1993	1,827	32	32	337	9.5%
1994	2,129	73	73	445	16.4%
1995	3,575	0	0	447	0.0%
1996	960	0	0	483	0.0%
1997	1,259	0	0	405	0.0%
1998	1,602	0	25	421	0.0%
1999	1,154	0	15	598	0.0%
2000	827	0	48		
2001	525	0	0		
2002	826	0	0		
2003	840	11	11		
2004	1,010	30	30		
2005	1,248	25	55		
2006	1,034	51	89		
2007	1,139	0	0		
Averages					
27-year (1981-2007)	1,428	49	24	466	10.6%
10-year (1997-2006)	1,033	12	27	546	2.1%
5-year (2002-2006)	992	23	37		
2007 as % of 5-year	115%	0%	0%		

[a] Mills 1982–1994; Howe et al. 1995, 1996, 2001a-d; Walker et al. 2003; Jennings et al. 2004, 2006a-b, 2007, 2009a-b, 2010.

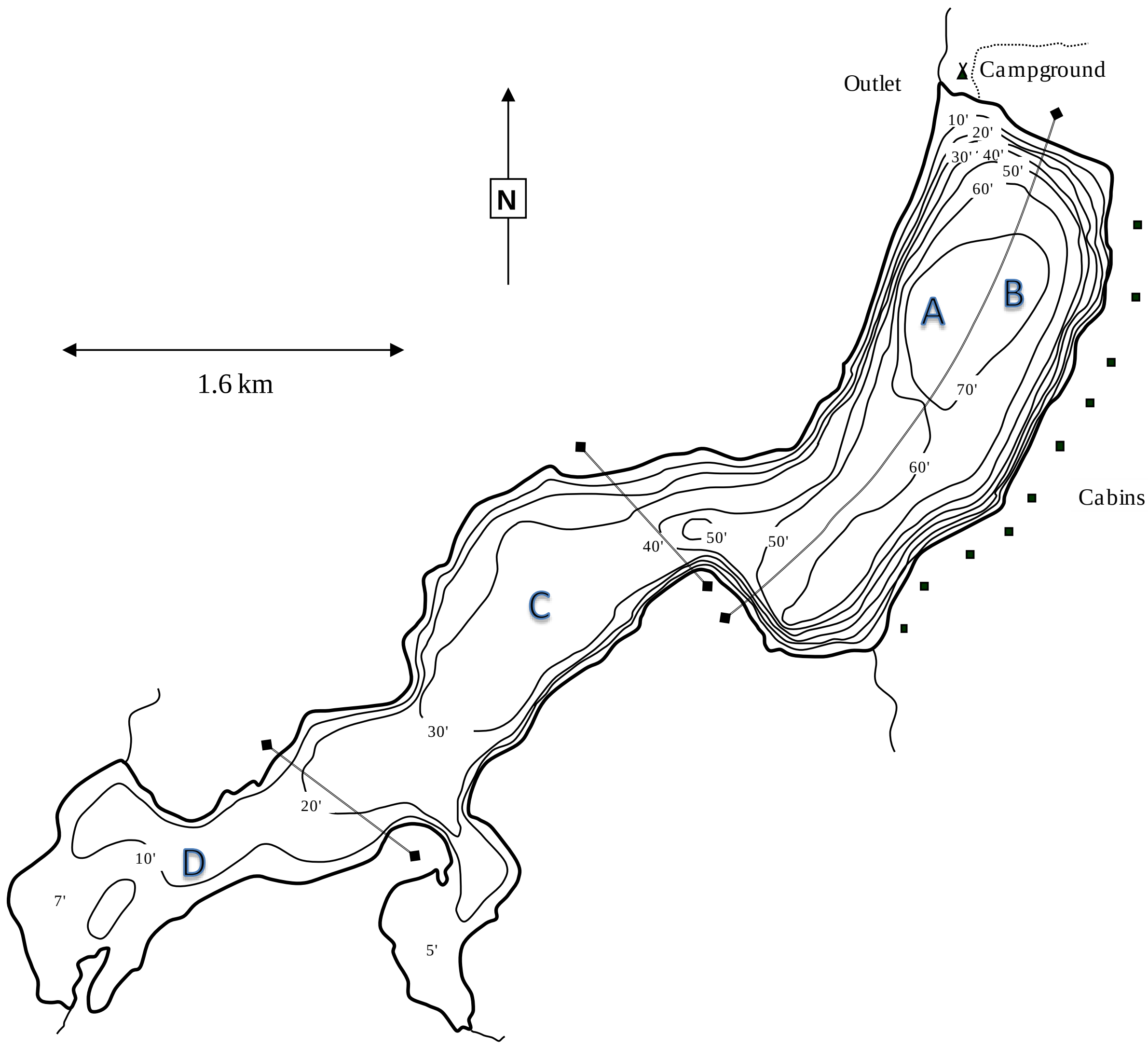

Figure 2.–Fielding Lake with sampling areas (A–D) demarcated.

METHODS

SAMPLING DESIGN AND FISH CAPTURE

To attain unbiased estimates of both CPUE and abundance, a two-sample mark-recapture experiment was conducted during which baited hoop traps were fished in a systematic manner as described by Bernard et al. (1993). The first sampling event occurred during 16–21 June and the second occurred during 8–13 September.

Burbot were captured in 3-m long baited hoop traps with 25-mm mesh netting placed on the bottom of the lake as described in Bernard et al. (1991). Each trap was baited with a 500-ml perforated plastic container filled with pieces of Pacific herring *Clupea pallasi* placed into the cod end of the hoop trap. Burbot ≥450 mm TL are fully recruited to this gear. Extremely large burbot (>900 mm TL) are not fully recruited to the gear (Bernard et al. 1991), but the proportion of fish >900 mm TL in Fielding Lake was negligible.

Traps were positioned according to a systematic sampling design as described in Bernard et al. (1993) to minimize competition among the gear while still covering the bottom of the lake. The number of transects selected depended upon the number of traps to be set. A grid of transects was placed over a map of the lake and transects were randomly removed until the desired number of possible sets was equal to the number of sets planned for each event (240). All transects were approximately 125 m apart, and traps along transects were set approximately 125 m apart. A set was defined as a single, baited hoop trap fished for approximately 48 h.

No traps were set deeper than 15 m to avoid decompression-induced mortality associated with burbot captured at greater depths (Bernard et al. 1993). Spring sampling commenced about a week after Fielding Lake became ice-free and fall sampling took place just prior to lake freeze-up. This timing helped to maximize the catch per set and to ensure accurate CPUE comparisons with past experiments (Bernard et al. 1993).

Traps were immersed and retrieved during daylight hours beginning on one end of the lake and progressed to the other end. A single crew of 3 persons (1 person piloted the boat and recorded data while the other 2 persons handled traps, measured, and tagged captured burbot) immersed and retrieved traps. The crew set and retrieved 60 traps in an 8-h workday. Every new set received fresh bait, and old bait was discarded.

ABUNDANCE

Abundance of burbot ≥450 mm FL was estimated using a two-event Petersen mark-recapture experiment (Seber 1982) designed to satisfy five assumptions:

1. the population was closed (burbot did not enter the population, via growth or immigration, or leave the population, via death or emigration, during the experiment);
2. all burbot had a similar probability of capture in the first event or in the second event, or marked and unmarked burbot mixed completely between events;
3. marking of burbot in the first event did not affect the probability of capture in the second event;
4. marked burbot were identifiable during the second event; and
5. all marked burbot were reported when examined during the second event.

The estimator used was a modified form of the Petersen estimator (Seber 1982):

$$\hat{N} = \frac{n_2 n_1}{m_2} \tag{1}$$

where:

n_1 = the number of fully recruited burbot marked and released during the first event;

n_2 = the number of fully recruited burbot examined for marks during the second event; and,

m_2 = the number of marked fully recruited burbot recaptured during the second event.

The sampling design and data collected allowed the validity of the five assumptions to be ensured or tested. The specific form of the estimator was determined from the experimental design and the results of diagnostic tests performed to evaluate if the assumptions were met

(Appendices A1–A3). The design also ensured that sample sizes were adequate to meet objective precision criteria and to perform reliable diagnostic tests.

Assumption 1: The inlet streams and outlets do not provide suitable habitat for burbot. The relatively long hiatus (nearly three months) between events increased the potential for closure violations due to growth recruitment and mortality. However, mortality and emigration will not bias the estimate as long as these happen at the same rate for marked and unmarked fish, and growth recruitment between events is typically insignificant for burbot ≥450 mm TL (Bernard et al. 1993).

Assumption 2: The 3-month hiatus between events promoted mixing of marked and unmarked fish. Bernard et al. (1993) found that marked and unmarked burbot can completely mix in as little as 2–3 weeks with crude sampling densities of 0.9–3.6 hectares/set. The relatively uniform distribution of sampling effort also helped to ensure that fish were subjected to equal capture probabilities during the first or second event in case mixing was not complete.

Assumption 3: Bernard et al. (1991 and 1993) showed that burbot caught in hoop traps exhibited no evidence of trap induced behavior (trap shyness/happiness) for a prolonged hiatus (e.g. >1 month) and burbot captured at depths <15 m showed no ill effects of being captured. The 3-month hiatus between events allowed marked fish to recover from any possible effects handling and marking had on them.

Assumptions 4: This assumption was addressed by double marking each burbot during the first event. Tag loss was noted when a fish was recovered during the second event with a first-event fin clip and without a Floy® tag. In addition, tag placement was standardized which enabled the fish handler to verify tag loss by locating recent tag wounds.

Assumption 5: These assumptions were ensured by the sampling and tagging methods see (Data Collection below).

DATA COLLECTION

Captured fish from each set were temporarily held in a tub, measured for length (mm TL), and carefully examined for marks. During the first event burbot ≥300 mm TL were tagged with an individually numbered internal anchor tag and given a secondary mark (left ventral fin clip). During the second event, fish were given a right ventral fin clip to prevent resampling.

Any burbot that was stressed from deep-water removal (usually resulting in an expanded gas bladder) or had trap-inflicted injuries was killed and dissected. Otoliths were removed, and the sex, weight (kg), and maturity of these burbot were recorded. Ages were estimated from whole, polished otoliths by counting annuli according to the method of Beamish and McFarlane (1987) and Chilton and Beamish (1982).

Individual trap and associated catch information were recorded on standardized hoop-net mark-sense forms for all lakes.[1] Data forms were optically scanned and electronic data files (ASCII format) were produced for archival (Appendix C) and were imported into Excel spreadsheets for data analysis. Trap information included: GPS location, sampling section (A–D), hoop trap number, location of set, depth of set, hour set and pulled, and number of fish caught by species.

[1] Heineman, G. *Unpublished*. Instructions for using sport fish creel survey and biological mark-sense forms. Alaska Department of Fish and Game, Draft Special Publication, Anchorage.

Total length, tag number and color, secondary mark, fate, and recapture status were recorded on the mark-sense form for each burbot caught in each set, unless the burbot was too small to tag (<300 mm TL).

DATA ANALYSIS

CPUE

CPUE was defined as the number of fish caught per trap fished over a 48-h period. Mean CPUE was estimated for fully and partially recruited burbot for each event following a 2-stage sampling design with transects as first-stage units and sets along transects as second-stage units (Bernard et al. 1993; Sukhatme et al. 1984). Although all transects had an equal probability of being included in a sample event, they were of different lengths because of the irregular shape of the lake. Under these conditions, an unbiased estimate of mean CPUE was:

$$\overline{CPUE} = \frac{1}{n}\sum_{i=1}^{n}\frac{1}{m_i}\sum_{j=1}^{m_i}\omega_i c_{ij} \qquad (2)$$

where:

c_{ij} = catch of burbot from the jth set on the ith transect;

n = number of transects;

m_i = number of sets sampled on the ith transect;

ω_i = $M_i / \overline{M}$;

M_i = maximum possible sets on the ith transect; and,

$\overline{M}$ = mean of possible sets across all transects.

Although the M_i and $\overline{M}$ are unknown, the m_i and m were used as substitutes because both M and m are directly related to the length of transects. Thus $\varpi_i = m_i/m$ was used to estimate ω_i. Because few burbot enter traps during daylight (Bernard et al. 1991), catches were not adjusted for the few hours deviation in soak times from the standard 48-h for most sets. A two-stage resampling procedure (Efron 1982; Rao and Wu 1988) was used to generate an empirical distribution of mean CPUE for each sample event from which variance of mean CPUE and bias from using ω_i were estimated. In resampling procedures, sets were chosen randomly within each transect although the original selection of sets was systematic. Systematically drawn data can be treated as randomly drawn with little concern for bias in the resultant statistics only so long as these data are not auto-correlated or follow a trend (Wolter 1984). Analysis of data from previous surveys has revealed no meaningful trends or autocorrelations among catches along transects (Bernard et al. 1993). Estimates of mean CPUE for two groups of burbot (≥450 mm and <450 mm TL) were calculated for each sample event using procedures described in Bernard et al. (1993). The computer program RAOWU.EXE was used to estimate mean CPUE, approximate its variance, and estimate inherent bias in the estimate according to a two-stage bootstrap procedure based on a model in Rao and Wu (1988). Individual burbot captured more than once in a given year were considered different fish each time captured in calculation of mean CPUE.

Conditions for the accurate calculation of mean CPUE as an index of abundance were:

1. gear did not compete for burbot;
2. burbot did not saturate the gear; and,
3. gear was not size-selective.

Bernard et al. (1993) showed that the spacing of sets used in this project (125 m) was sufficient to avoid competition among gear for burbot and that saturation of gear by burbot was negligible. Because hoop traps fished in this project were size-selective for burbot (Bernard et al. 1991, 1993), only mean CPUE for fully recruited burbot was considered as a valid index of abundance. Also, because captured burbot take as many as 2–3 weeks to fully adjust to the effects of capture and handling (Bernard et al. 1991), CPUE from only the first pass of each event (if more than one is conducted) is used for future CPUE comparisons.

ABUNDANCE AND LENGTH COMPOSITION

Violations of Assumption 2 relative to size effects were tested using two Kolmogorov-Smirnov (K-S) tests. There were four possible outcomes of these two tests relative to evaluating size selective sampling (either one of the two samples, both, or neither of the samples were biased) and two possible actions for abundance estimation (length stratify or not). The tests and possible actions for data analysis are outlined in Appendix A2. If stratification by size was required, capture probabilities by location were examined for each length stratum.

The tests for consistency of the Petersen estimator (Seber 1982; Appendix A3) were used to determine the appropriate abundance estimator and whether stratification by location was required. Depending on the outcome of these tests, either the pooled Chapman-modified Petersen estimator, the completely stratified Chapman-modified Petersen estimator, or a partially stratified estimator (Darroch 1961) would be used.

Documentation of release locations of each fish permitted the examination of multiple geographic stratification schemes for purposes of assumption testing, and final testing was performed at the scales of the 4 predefined sampling sections (A–D). Length composition was estimated in 50-mm length categories for burbot ≥450 mm TL following procedures described in Appendix A4.

RESULTS

ABUNDANCE AND LENGTH COMPOSITION

During both sampling events in 2008, a total of 731 burbot were captured and measured for length, of which 715 were ≥300 mm TL and included in the analyses. Of the fully recruited fish (≥450 mm TL), 301 were marked and released in the first event (n_1), 156 were captured and examined for marks in the second event (n_2), and 52 were marked fish recaptured in the second event (m_2). Included in the 52 recaptures were 3 fish that had lost tags between sampling events.

Of the partially recruited fish (300 - 449 mm TL), 94 were marked and released in the first event (n_1), 164 were captured and examined for marks in the second event (n_2), and 3 were marked fish recaptured in the second event (m_2).

Based on the diagnostic procedures outlined in Appendix A2, K-S test results indicated that sampling was not size selective (i.e., Case I) and stratification by length was not required for burbot ≥450 mm TL (Figure 3). No significant differences were observed when comparing n_1 vs. m_2 (D = 0.15, p-value = 0.20) or n_2 vs. m_2 (D = 0.126, p-value = 0.07).

During the course of the experiment, 21 of 57 fish bearing Floy tags were recaptured in the same section in which they were marked (Table 2). Between the two events, considerable movements were observed and the average straight-line distance moved was 1.6 km (Appendix B). Results of the consistency tests indicated that geographic stratification was not needed (Table 2) and that complete mixing was achieved.

Using the Chapman-modified Petersen estimate, the abundance estimate for burbot ≥450 mm TL was 894 (SE = 90). Density of fully recruited burbot was 1.66 fish per hectare. Most of these fish were within the 500-549 mm length category (Table 3).

The length distribution of fish ≥450 mm TL captured during the first and second events were similar. However, the length distribution of fish ≥300 mm TL from the second event had a higher frequency of smaller fish and lower frequency of larger fish (Figure 4).

Thirteen burbot released in 1999 and 2000 and were recaptured in 2008 (8 and 9 years between capture) and grew an average of 225 mm or 27 mm/year (Appendix C1). Twelve burbot were killed incidental to sampling and the maximum age was 9 years for a fish that was 471 mm TL (Appendix C2).

CPUE

In June 2008, estimated mean CPUE of burbot ≥450 mm TL was 1.30 (SE = 0.15; Table 4). Estimated bias in mean CPUE calculated through bootstrapping was negligible (< 1%). Sets were most numerous between 7 m and 9 m deep during both events. Largest numbers of fully recruited burbot were caught in deeper waters (16m–18 m) and partially recruited burbot were caught most in shallower sets (Figure 5).

In September 2008, estimated mean CPUE of burbot ≥450 mm TL was 0.65 (SE = 0.15) per set (Table 4). Estimated bias in mean CPUE calculated through bootstrapping was negligible (< 1%). Fully-recruited burbot were mostly caught in deeper sets and partially recruited burbot in shallower water (Figure 6).

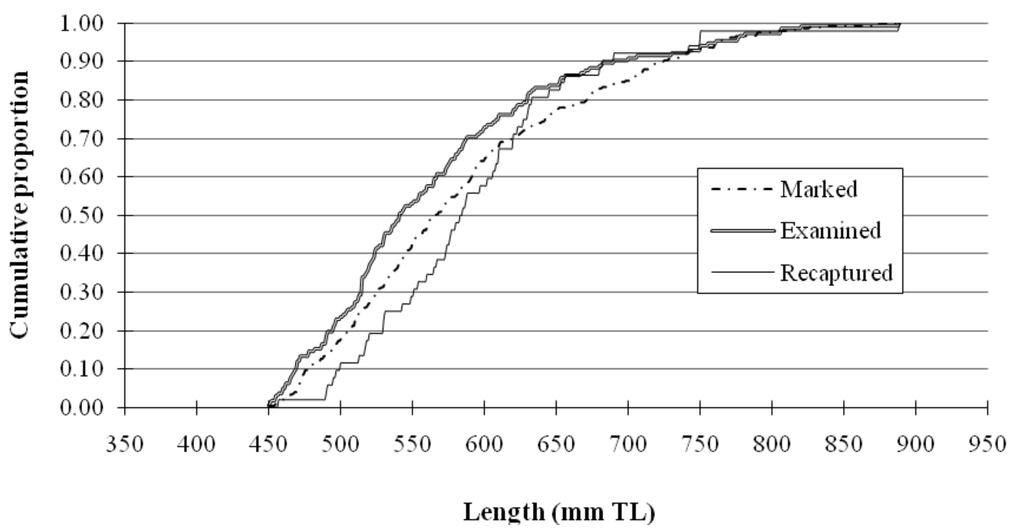

Figure 3.–Cumulative proportion of burbot ≥450 mm TL marked (n_1), examined (n_2), and recaptured (m_2) during sampling events in Fielding Lake, 2008.

Table 2.–Number of burbot ≥450 mm TL marked (n_1), examined (n_2), and recaptured (m_2); and results of consistency tests (Appendix A3) by location relative to sampling sections (A–D) of the study area in Fielding Lake, 2008.

		Section where recaptured				Total Recaptured	Total Marked	$P_{capture}$ 2nd event
		D	C	B	A	(m_2)	(n_1)	(m_2/n_1)
Section where marked	D	1	1	2	2	6	46	0.13
	C	3	10	3	6	22	95	0.23
	B	1	3	7	5	16	99	0.16
	A	2	2	1	3	8	61	0.13
Total Recaptured (m_2)		7	16	13	16			
Total Examined (n_2)		31	48	52	25			
$P_{capture}$ 1st Event (m_2/n_1)		0.23	0.33	0.25	0.64			

Test I: (mixing): $\chi^2 = 8.49$, df = 9, P-value = 0.74, fail to reject H_0.

Test II: (2nd event capture probabilities by section): $\chi^2 = 13.82$, df = 3, P-value = 0.003, reject H_0.

Test III: (1st event capture probabilities by section): $\chi^2 = 3.70$, df = 3, P-value = 0.29, fail to reject H_0.

Table 3.–Number of fish sampled (n), estimated proportion ($\hat{\rho}$), and estimated abundance ($\hat{N}$) by length category for the population of burbot ≥450 mm TL in Fielding Lake, 2008.

Length (mm TL)	n	$\hat{\rho}$	$V[\hat{\rho}]$	$\hat{N}$	$V[\hat{N}]$	SE	CV
450-499	88	0.19	0.018	172	570	24	13.9%
500-549	121	0.27	0.021	237	905	30	12.7%
550-599	97	0.21	0.019	190	655	26	13.5%
600-649	56	0.12	0.015	110	308	18	16.0%
650-699	35	0.08	0.012	68	170	13	19.1%
700-749	29	0.06	0.011	57	136	12	20.5%
750-799	20	0.04	0.010	39	88	9	24.0%
800-849	8	0.08	0.006	16	32	6	36.3%
850+	3	0.01	0.004	6	12	3	58.2%
	457			894	8,095	90	10.1%

Table 4.–Estimated mean CPUE of fully recruited (≥450 mm TL) and partially recruited (300-449 mm TL) burbot captured from all depths during the first (6/16–6/21) and second (9/8–9/13) sampling events at Fielding Lake, 2008.

Category	Number of transects	Number of sets	$\overline{CPUE}$	SE	CV%
First event					
≥450 mm	240	51	1.30	0.147	11.3
300-449 mm	240	51	0.45	0.08	17.3
Second event					
≥450 mm	240	50	0.65	0.09	14.1
300-449 mm	240	50	0.68	0.10	15.2

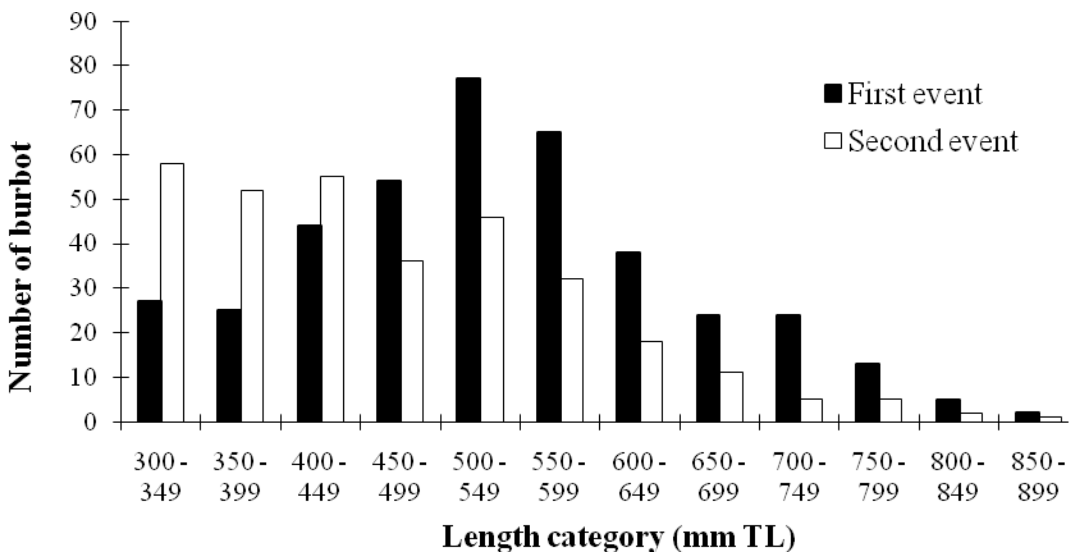

Figure 4.–Number of burbot by 50-mm length groups captured during sampling efforts in Fielding Lake, 2008.

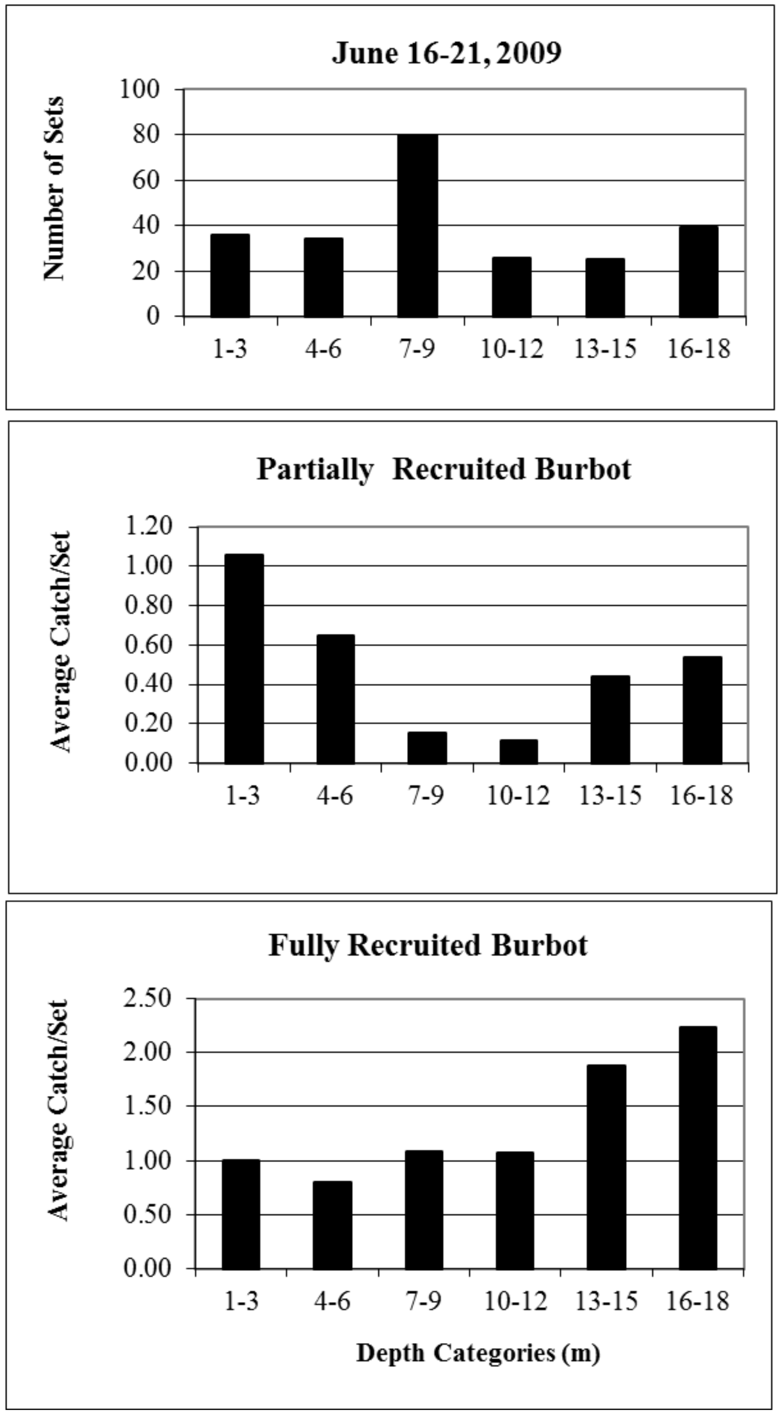

Figure 5.–Number of sets (upper graph), and average catch per set for partially and fully recruited burbot (middle and lower graphs) by depth at Fielding Lake during 16–21 June, 2008.

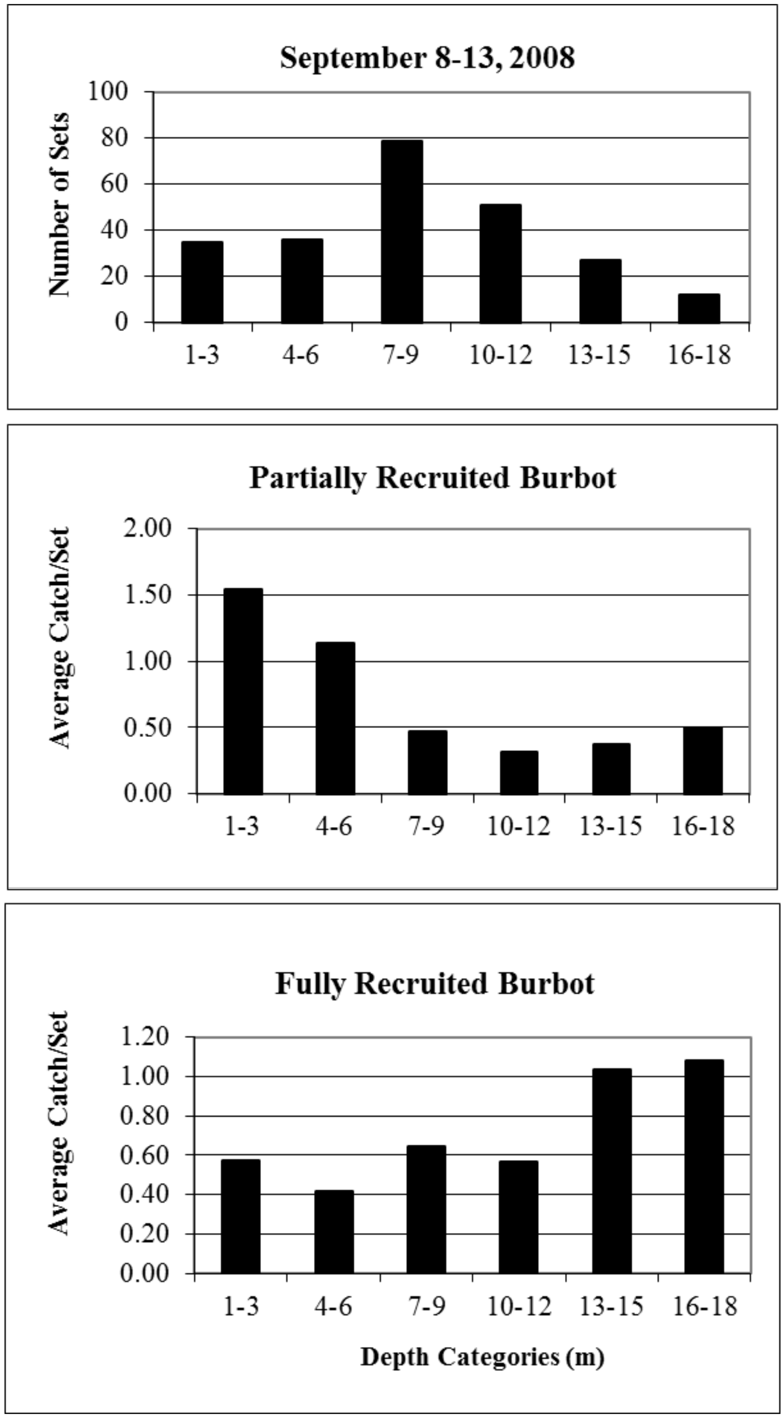

Figure 6.–Number of sets (upper graph), and average catch per set for partially and fully recruited burbot by depth (middle and lower graphs) at Fielding Lake during 8–13 September, 2008.

DISCUSSION

The results demonstrated that the population of burbot has increased relative to abundance and size composition. The estimated abundance in 2008 was greater than all previous estimates (Figure 7). Statistically, the length distributions between 2000 and 2008 are different (Figure 8). Average length of burbot increased from 530 mm TL in 2000 (Parker 2001) to 585 mm TL in 2008 and it appeared that greater numbers of small burbot recruited into the population.

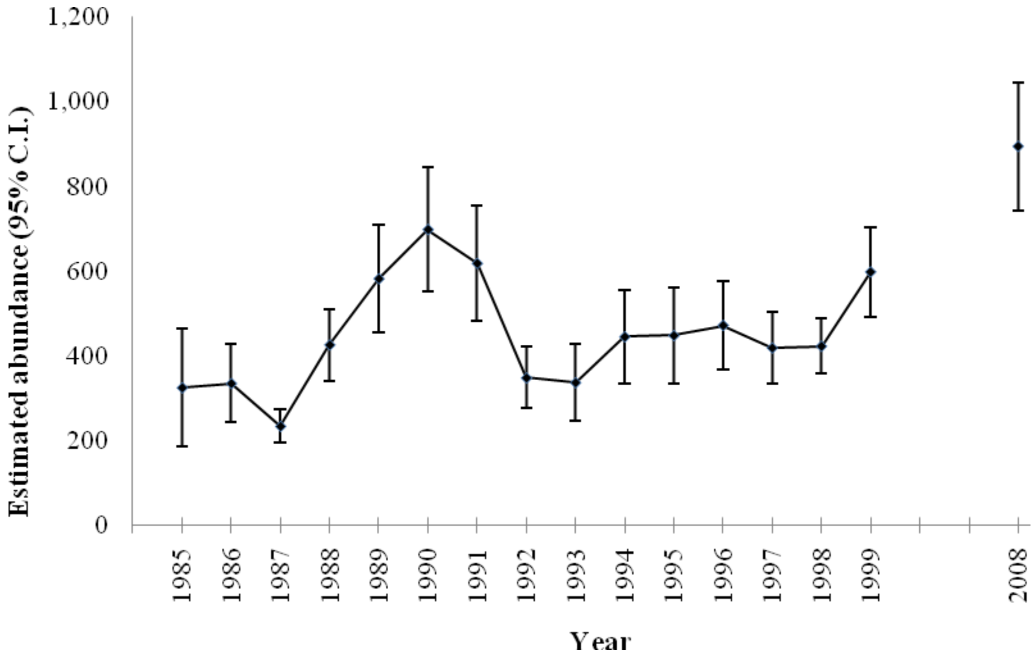

Figure 7.–Estimated abundance of burbot ≥450 mm TL in Fielding Lake.

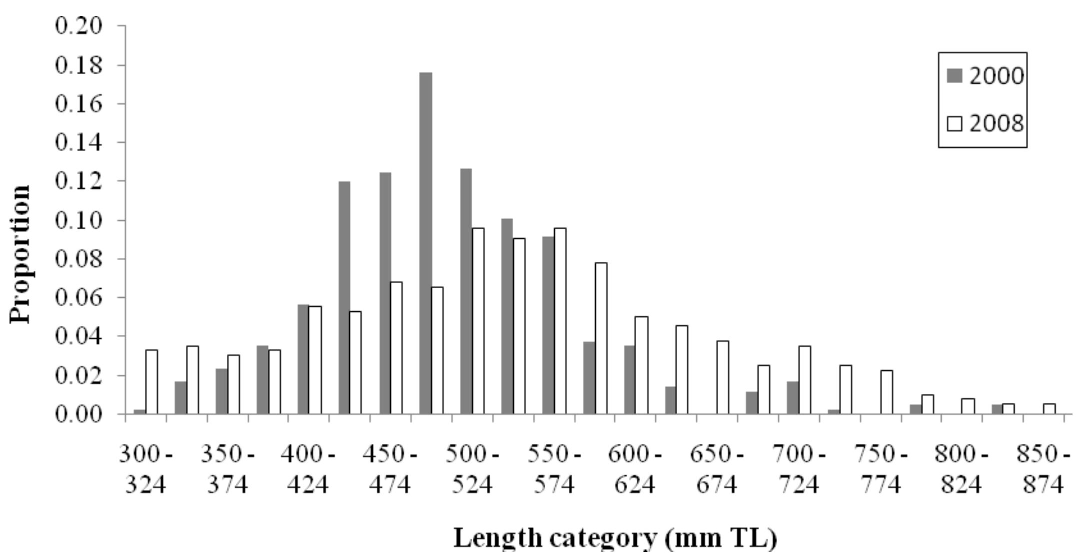

Figure 8.–Comparison of length compositions of all burbot sampled from Fielding Lake during June of 2000 and 2008.

The increase in abundance between 2000 and 2008 was not reflected by an increase in mean CPUE. In the spring of 2000, mean CPUE for burbot ≥450 mm TL was 1.32 (SE = 0.15; Parker 2001) that was nearly identical to the value of 1.30 (SE = 0.15) in 2008. One explanation for why CPUE did not increase between 2000 and 2008 may be attributed to placement of sets between the two events. In June of 2000, traps were set at all depths across the entire lake whereas in 2008, traps were restricted to water less than 16 meters to prevent mortality due to deep water removal. In 2008, the highest CPUE was in deeper waters where fewer sets were made while only moderate catches were experienced in waters 7–9 meters in depth (Figure 6). In 2000, the greatest numbers of sets during June were in waters 9–12 meters, which also had the greatest CPUE by depth category (Parker 2001). It appears that in 2008, if sets were apportioned across all depths like it was in 2000, then CPUE would be overall higher. In 2008, sampling occurred slightly earlier (16 June), about one week than in 2000 (20 June), which also may have caused a difference in distribution of fish in the lake.

Although there are no estimates of abundance of burbot in Fielding Lake available for years prior to 1985, it appears that the population has recovered from the high exploitation that occurred in the early 1980s as the estimated abundance of burbot ≥450 mm TL in 2008 is nearly twice as large as the estimated abundance in 1985. From 1994 to 2000 Fielding Lake was closed to the taking of burbot and in 2001 the Alaska Board of Fisheries passed new regulations, which allowed a one-burbot daily bag and possession limit, prohibited the use of setlines, and imposed a single hook restriction. Because of conservation concerns for lake trout, current regulations for Fielding Lake have restricted the use of bait since 2007, making it difficult for anglers to catch burbot. Maintaining harvests such that annual exploitation rates do not exceed 10% is thought to be a conservative guideline to prevent excessive harvest on this burbot population, which currently equates to about 90 fish per year. Current regulations will likely ensure annual harvests remain below 90 fish unless anglers can develop techniques to catching burbot on artificial lures.

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APPENDIX A: EQUATIONS AND STATISTICAL METHODOLOGY FOR ESTIMATING ABUNDANCE AND LENGTH COMPOSITION

Appendix A1.-Equations for calculating estimates of abundance and its variance using the Chapman's modification of the Petersen estimator (Seber 1982).

The Chapman estimator (Seber 1982) is the simplest case, fish are randomly collected from a closed population, and the Chapman estimator and its variance are:

$$\hat{N} = \frac{(n_2 + 1)(n_1 + 1)}{(m_2 + 1)} - 1; \tag{A1-1}$$

$$\hat{V}[\hat{N}] = \frac{(n_1 + 1)(n_2 + 1)(n_1 - m_2)(n_2 - m_2)}{(m_2 + 1)^2 (m_2 + 2)} \tag{A1-2}$$

where:

n_1 = the number of fully recruited burbot marked during the first sampling event;

n_2 = the number of fully recruited burbot examined during the second sampling event; and,

m_2 = the number of fully recruited burbot captured during the second sampling event with marks from the first sampling event.

Appendix A2.-Procedures for detecting and adjusting for size or sex selective sampling during a 2-sample mark recapture experiment.

Overview

Size and sex selective sampling may result in the need to stratify by size and/or sex in order to obtain unbiased estimates of abundance and composition. In addition, the nature of the selectivity determines whether the first, second or both event samples are used for estimating composition. The Kolmogorov-Smirnov two sample (K-S) test (Conover 1980) is used to detect significant evidence that size selective sampling occurred during the first or second sampling events and contingency table analysis (Chi-square test) is generally used to detect significant evidence that sex selective sampling occurred during the first or second sampling events.

K-S tests are used to evaluate the second sampling event by comparing the length frequency distribution of all fish marked during the first event (M) with that of marked fish recaptured during the second event (R), using the null test hypothesis (H_o) of no difference. The first sampling event is evaluated by comparing the length frequency distribution of all fish inspected for marks during the second event (C) with that of R. Chi-square tests are used to compare the counts of observed males to females between M&R and C&R according to the null hypothesis that the probability that a sampled fish is male or female is independent of the sample. When the proportions by gender are estimated for a subsample (usually from C), rather than observed for all fish in the sample, contingency table analysis is not appropriate and the proportions of females (or males) are compared between samples using a two sample test (e.g., Student's t-test).

Mark-recapture experiments are designed to obtain sample sizes sufficient to 1) achieve precision objectives for abundance and composition estimates and 2) ensure that the diagnostic tests (i.e., tests for selectivity) have power adequate for identifying selectivity that could result in significantly biased estimates. Despite careful design, experiments may result in inadequate sample sizes leading to unreliable diagnostic test results due to low power. As a result, detection and adjusting for size and sex selectivity involves evaluating the power of the diagnostic tests.

The protocols that follow are used to classify the experiment into one of four cases. For each case the following are specified: 1) whether stratification is necessary, 2) which sample event's data should be used when estimating composition, and 3) the estimators to be used for composition estimates when stratifying. The first protocols assume adequate power. These are followed by supplemental protocols to be used when power is suspect and guidelines for evaluating power.

Protocols given Adequate Power

Case I:

M vs. R	**C vs. R**
Fail to reject H_o	Fail to reject H_o

There is no size/sex selectivity detected during either sampling event. Abundance is calculated using a Petersen-type model from the entire data set without stratification. Composition parameters may be estimated after pooling length, sex, and age data from both sampling events but do not include recaptured fish twice.

Case II:

M vs. R	**C vs. R**
Reject H_o	Fail to reject H_o

There is no size/sex selectivity detected during the first event but there is during the second event sampling. Abundance is calculated using a Petersen-type model from the entire data set without stratification. Composition parameters may be estimated using length, sex, and age data from the first sampling event without stratification. If composition is estimated from second event data or after pooling both sampling events, data must first be stratified to eliminate variability in capture probability (detected by the M vs. R test) within strata. Composition parameters are estimated within strata, and abundance for each stratum needs to be estimated using a Petersen-type formula.

-continued-

Overall composition parameters are estimated by combining stratum estimates weighted by estimated stratum abundance according to the formulae below.

Case III:

M vs. R	**C vs. R**
Fail to reject H_o	Reject H_o

There is no size/sex selectivity detected during the second event but there is during the first event sampling. Abundance is calculated using a Petersen-type model from the entire data set without stratification. Composition parameters may be estimated using length, sex, and age data from the second sampling event without stratification. If composition is estimated from first event data or after pooling both sampling events, data must first be stratified to eliminate variability in capture probability (detected by the C vs. R test) within strata. Composition parameters are estimated within strata, and abundance for each stratum needs to be estimated using a Petersen-type type formula. Overall composition parameters are estimated by combining stratum estimates weighted by estimated stratum abundance according to the formulae below.

Case IV:

M vs. R	**C vs. R**
Reject H_o	Reject H_o

There is size/sex selectivity detected during both the first and second sampling events. The ratio of the probability of captures for size of sex categories can either be the same or different between events. Data must be stratified to eliminate variability in capture probability within strata for at least one or both sampling events. Abundance is calculated using a Petersen-type model for each stratum, and estimates are summed across strata to estimate overall abundance. Composition parameters may be estimated within the strata as determined above, but only using data from sampling events where stratification has eliminated variability in capture probabilities within strata. If data from both sampling events are to be used, further stratification may be necessary to meet the condition of capture homogeneity within strata for both events. Overall composition parameters are estimated by combining stratum estimates weighted by estimated stratum abundance.

Protocols when Power Suspect (re-classifying the experiment)

When sample sizes are small (guidelines provided in next section) power needs to be evaluated when diagnostic tests fail to reject the null hypothesis. If this failure to identify selectivity is due to low power (that is, if selectivity is actually present) data will be pooled when stratifying is necessary for unbiased estimates. For example, if the both the M vs. R and C vs. R tests failed to identify selectivity due to low power, Case I may be selected when Case IV is true. In this scenario, the need to stratify could have been overlooked leading to biased estimates. The following protocols should be followed when sample sizes are small.

Case I:

M vs. R	**C vs. R**	**Implication**
Fail to reject Ho	Fail to reject Ho	re-evaluate both tests
Power OK/retain test result	Power OK/retain test result	Case I
Power suspect/change to Reject Ho	Power OK/retain test result	Case II
Power OK/retain test result	Power suspect/change to Reject Ho	Case III
Power suspect/change to Reject Ho	Power suspect/change to Reject Ho	Case IV

-continued-

Case II:

M vs. R	**C vs. R**	**Implication**
Reject Ho	Fail to reject Ho	re-evaluate C vs. R
	Power OK/retain test result	Case II
	Power suspect/change to Reject Ho	Case IV

Case III:

M vs. R	**C vs. R**	**Implication**
Fail to reject Ho	Reject Ho	re-evaluate M vs. R
Power OK/retain test result		Case III
Power suspect/change to Reject Ho		Case IV

Guidelines for evaluating power:

The following guidelines to assess power are based upon the experiences of Sport Fish biometricians; they have not been comprehensively evaluated by simulation. Because some "art" in interpretation remains these guidelines are not intended to be used in lieu of discussions with biometricians when possible. When the evaluation does not lead to a clear choice, a stratified estimator should be selected (i.e., the experiment should be classified as Case IV) in order to minimize potential bias.

The reliability of M vs. R and C vs. R tests that fail to reject H_o are called into question when 1) sample sizes M or C are < 100 and the sample size for R is < 30, 2) p-values are not large (~0.20 or less), and the D statistics are large (≥ 0.2). If sample sizes are small, the p-value is not large, and the D statistic is large then the power of the test is suspect and, when re-classifying the experiment, the test should be considered as having rejected the null hypothesis. If for example, sample sizes are marginal (close to the recommended values), the p-value is large, and the D-statistic is not large then the test result may be considered reliable. It is when results are close to the recommended "cutoffs" that interpretation becomes somewhat more complicated.

Apparent inconsistencies between the combination of the M vs. R and C vs. R test results and the M vs. C test results may also arise from low power. For example, if one of the tests involving R rejects the null hypothesis and the other fails to reject one could infer a difference between M & C; however, the M vs. C test may still fail to reject the null indicating no difference between the M & C. In this case, the apparent inconsistency may be due to low power in the test involving R that failed to reject the null. Finally, an additional Case I scenario is flagged by an apparent inconsistency between test results, this time resulting from power being too high. Under this scenario both the M vs. R and C vs. R tests fail to reject the null hypothesis and their power is thought to be sufficient; however, the M vs. C test rejects H_o: no difference between the M & C. The apparent inconsistency may result from the M vs. C test being so powerful as to detect selectivity that would result in insignificant bias when estimating abundance and composition. The reliability of M vs. C tests that reject are called into question when 1) sample sizes M or C are > 500, 2) p-values are not extremely small (~0.010-0.049), and the D statistics are small (<0.08). In general all three K-S tests should be performed to permit these evaluations.

Appendix A3.–Tests of consistency for the Petersen estimator (from Seber 1982, page 438).

The following two assumptions must be fulfilled:

1. catching and handling the fish does not affect the probability of recapture; and,
2. marked fish do not lose their mark.

Of the following assumptions, only one must be fulfilled:

1. marked fish mix completely with unmarked fish between events;
2. every fish has an equal probability of being marked and released during event 1; or,
3. every fish has an equal probability of being captured during event 2.

To evaluate these three assumptions, the chi-square statistic will be used to examine the following contingency tables as recommended by Seber (1982). At least one null hypothesis needs to be accepted for assumptions of the Petersen model (Bailey 1951, 1952; Chapman 1951) to be valid. If all three tests are rejected, a geographically stratified estimator (Darroch 1961) should be used to estimate abundance.

TEST I[a]

First Event Sampling Area Released	Second Event				
	Sampling Area Recaptured				Not Recaptured
	A	**B**	**…**	**S**	(total)
A					
B					
…					
S					

TEST II[b]

	Second Event: Sampling Area			
	A	**B**	**…**	**S**
Recaptured				
Not Recaptured				

TEST III[c]

	Captured During Second Event			
	A	**B**	**…**	**S**
Marked				
Unmarked				

[a] This tests the hypothesis that movement probabilities are the same among sections: H_1: $\theta_{ij} = \theta_j$. Theta applies to both marked and unmarked fish.

[b] This tests the hypothesis of homogeneity on the columns of this 2-by-s contingency table with respect to recapture probabilities between the three lake areas: H_2: $\Sigma_j \theta_{ij} p_j = d$. Theta applies to both marked and unmarked fish.

[c] This tests the homogeneity on the columns of the 2-by-t contingency table with respect to the probability of movement of marked fish in stratum *i* to the unmarked fraction in *j*: H_4: $\Sigma_i a_i \theta_{ij} = kU_j$. Theta only applies to marked fish.

Appendix A4.–Equations for estimating length, age composition, and their variances for the population.

For Case I-III scenarios (Appendix A2), the proportions of burbot within each age or length class *k* were estimated:

$$\hat{p}_k = \frac{n_k}{n} \tag{A4-1}$$

where:

n_k = the number of burbot sampled within age or length class *k* and,

n = the total number of burbot sampled.

When calculating n and n_k the diagnostic test results were used to determine the fish were included (Appendix A2). For Case I, used fish from both events and for Case II used first event fish.

The variance of each proportion was estimated as (from Cochran 1977):

$$\hat{V}[\hat{p}_k] = \frac{\hat{p}_k(1-\hat{p}_k)}{n-1}. \tag{A4-2}$$

The abundance of burbot in each length or age category, *k,* in the population was then estimated:

$$\hat{N}_k = \sum_{k=1}^{s} \hat{p}_k \hat{N}, \tag{A4-3}$$

where:

$\hat{N}$ = the estimated overall abundance (Appendix A1); and,

s = the number of age or length classes.

The variance for $\hat{N}_k$ was then estimated using the formulation for the exact variance of the product of two independent random variables (Goodman 1960):

$$\hat{V}\left[\hat{N}_k\right] \approx \sum_{k=1}^{s} \left(\hat{V}[\hat{p}_k]\hat{N}^2 + \hat{V}\left[\hat{N}\right]\hat{p}_k^2 - \hat{V}[\hat{p}_k]\hat{V}\left[\hat{N}\right] \right). \tag{A4-4}$$

-continued-

For the Case IV scenario (Appendix A2), requiring stratification by size or sex, the proportions of burbot within each age or length class *k* were estimated by first calculating:

$$\hat{p}_{jk} = \frac{n_{jk}}{n_j} \qquad \textbf{(A4-5)}$$

where:

n_j = the number sampled from size stratum *j* in the mark-recapture experiment;

n_{jk} = the number sampled from size stratum *j* that are in length or age category *k*; and,

$\hat{p}_{jk}$ = the estimated proportion of length or age category *k* fish in size stratum *j*.

When calculating n_j and n_{jk} the within stratum diagnostic test results were used to determine which fish were included in the analysis following the rules for *n* and n_k provided above.

The variance calculation for $\hat{p}_{jk}$ is equation 2 substituting $\hat{p}_{jk}$ for $\hat{p}_k$ and n_j for *n*.

The estimated abundance of fish in length or age category *k* in the population is then:

$$\hat{N}_k = \sum_{j=1}^{s} \hat{p}_{jk} \hat{N}_j \qquad \text{(A4-6)}$$

where:

$\hat{N}_j$ = the estimated abundance in size stratum *j*; and,

s = the number of size strata.

The variance for $\hat{N}_k$ will be estimated using the formulation for the exact variance of the product of two independent random variables (Goodman 1960):

$$\hat{V}\left[\hat{N}_k\right] = \sum_{j=1}^{s} \left(\hat{V}\left[\hat{p}_{jk}\right]\hat{N}_j^2 + \hat{V}\left[\hat{N}_j\right]\hat{p}_{jk}^2 - \hat{V}\left[\hat{p}_{jk}\right]\hat{V}\left[\hat{N}_j\right] \right). \qquad \text{(A4-7)}$$

-continued-

The estimated proportion of the population in length or age category k $(\hat{p}_k)$ is then:

$$\hat{p}_k = \hat{N}_k \big/ \hat{N} \tag{A4-8}$$

where: $\hat{N} = \sum_{j=1}^{s} \hat{N}_j$.

Variance of the estimated proportion can be approximated with the delta method (Seber 1982):

$$\hat{V}[\hat{p}_k] \approx \sum_{j=1}^{s} \left\{ \left(\frac{\hat{N}_j}{\hat{N}} \right)^2 \hat{V}[\hat{p}_{jk}] \right\} + \frac{\sum_{j=1}^{s} \left\{ \hat{V}[\hat{N}_j] (\hat{p}_{jk} - \hat{p}_k)^2 \right\}}{\hat{N}^2} . \tag{A4-9}$$

APPENDIX B: BURBOT MOVEMENT IN FIELDING LAKE

Appendix B 1.–Burbot movement data including trap number, transect coordinates (x,y), set depth, fish length, tag number, section location, GPS coordinates and movement between captures for each fish recaptured in the second recapture event.

Trap#	(x)	(y)	Depth	Len	Tag	Loc	WGS-84 (datum)	Trap#	(x)	(y)	Depthh	Len	Tag	Move (mi)	loc	WGS-84 (datum)
5	33	1	40	519	21841	C	N63 10.496 W145 40.526	95	33	8	38	577	21841	0.30	3	N63 10.296 W145 40.241
331	1	2	4	545	81352	A	N63 09.446 W145 44.023	10	2	2	2	549	81352	0.03	1	N63 09.432 W145 43.984
331	1	2	4	585	81353	A	N63 09.446 W145 44.023	166	14	5	26	495	81353	1.00	2	N63 09.657 W145 42.224
134	6	1	11	504	81413	A	N63 09.736 W145 43.664	72	34	1	40	530	81413	2.10	3	N63 10.495 W145 40.488
19	7	3	10	394	81418	A	N63 09.557 W145 43.075	19	3	1	2	409	81418	0.50	1	N63 09.523 W145 44.066
12	10	3	19	870	81428	A	N63 09.644 W145 42.687	5	50	5	12	888	81428	3.10	4	N63 11.101 W145 38.218
12	10	3	19	748	81429	A	N63 09.644 W145 42.687	91	43	1	49	750	81429	2.70	3	N63 11.091 W145 39.153
41	12	1	19	625	81441	A	N63 09.804 W145 42.591	61	50	2	30	633	81441	2.90	4	N63 11.307 W145 38.429
55	13	1	16	615	81443	B	N63 09.867 W145 42.527	22	4	6	7	623	81443	0.60	1	N63 09.470 W145 43.387
42	14	5	25	533	81448	B	N63 09.678 W145 42.139	166	14	5	26	520	81448	0.05	2	N63 09.657 W145 42.224
Recaptured same event					81448	B	N63 09.657 W145 42.224	30	32	3	34	530	81448	1.10	2	N63 10.367 W145 40.608
4	14	4	27	415	81450	B	N63 09.748 W145 42.232	129	35	3	42	422	81450	1.40	3	N63 10.452 W145 40.153
3	15	2	23	603	81456	B	N63 09.899 W145 42.244	86	22	6	27	610	81456	0.30	2	N63 09.845 W145 41.653
17	15	4	25	541	81458	B	N63 09.816 W145 42.121	136	14	4	28	565	81458	0.20	2	N63 09.704 W145 42.267
93	15	7	20	626	81463	B	N63 09.665 W145 41.840	67	18	3	6	620	81463	0.40	2	N63 09.400 W145 41.792
8	20	3	25	618	81474	B	N63 09.787 W145 41.809	47	34	3	42	620	81474	1.10	3	N63 10.392 W145 40.265
8	20	3	25	534	81475	B	N63 09.787 W145 41.809	33	35	6	47	543	81475	1.60	4	N63 10.155 W145 39.524
70	22	3	29	671	81483	B	N63 10.005 W145 41.861	57	34	6	25	690	81483	1.40	4	N63 10.141 W145 39.694
94	24	5	30	531	81490	B	N63 09.997 W145 41.552	137	15	4	25	531	81490	0.40	2	N63 09.832 W145 42.190
92	24	1	27	494	81493	B	N63 10.220 W145 41.757	94	25	3	30	497	81493	0.09	2	N63 10.180 W145 41.632
110	25	6	31	717	81502	B	N63 09.990 W145 41.459	137	15	4	25	742	81502	0.40	2	N63 09.832 W145 42.190
108	26	7	29	595	81503	B	N63 09.989 W145 41.328	26	31	5	31	597	81503	0.50	2	N63 10.324 W145 40.695
106	26	5	30	675	81505	B	N63 10.073 W145 41.428	61	15	8	22	680	81505	0.50	2	N63 09.714 W145 41.938
39	26	4	30	610	81507	B	N63 10.137 W145 41.466	120	44	2	51	610	81507	1.50	4	N63 10.653 W145 38.730
104	27	1	26	710	81516	B	N63 10.397 W145 41.612	12	11	3	17	682	81516	1.10	1	N63 09.666 W145 42.717
104	27	1	26	510	81518	B	N63 10.397 W145 41.612	81	13	3	28	500	81518	1.00	1	N63 09.737 W145 42.452
46	29	4	33	550	81529	B	N63 10.201 W145 41.148	134	36	2	41	551	81529	0.70	3	N63 10.476 W145 40.008
9	29	1	29	760	81535	B	N63 10.363 W145 41.330	304	46	1	40	750	81535	1.90	3	N63 11.221 W145 39.181
101	31	3	29	590	81544	B	N63 10.337 W145 40.860	61	50	2	30	585	81544	1.80	4	N63 11.307 W145 38.429
135	31	1	27	550	81546	B	N63 10.461 W145 40.968	61	50	2	30	560	81546	1.90	4	N63 11.307 W145 38.429
135	31	1	27	594	81547	B	N63 10.461 W145 40.968	103	48	5	33	602	81547	1.40	4	N63 10.873 W145 38.431

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Appendix B.–Page 2 of 2.

Trap#	(x)	(y)	Depth	Len	Tag	Loc	WGS-84 (datum)	Trap#	(x)	(y)	Depthh	Len	Tag	Move (mi)	loc	WGS-84 (datum)
2	32	4	36	610	81550	C	N63 10.343 W145 40.656	65	42	2	43	588	81550	1.30	3	N63 11.076 W145 39.325
37	33	9	20	524	81553	D	N63 10.127 W145 39.856	57	34	6	25	513	81553	0.08	4	N63 10.141 W145 39.694
22	33	5	50	523	81568	C	N63 10.305 W145 40.193	11	26	1	27	518	81568	0.80	2	N63 10.335 W145 41.710
41	34	4	55	430	81585	C	N63 10.447 W145 40.271	42	31	4	33	431	81585	0.30	2	N63 10.369 W145 40.775
59	34	6	45	606	81590	D	N63 10.156 W145 39.649	130	25	4	31	606	81590	1.20	2	N63 10.133 W145 41.575
33	35	4	50	560	81598	C	N63 10.431 W145 39.982	33	35	6	47	573	81598	0.40	4	N63 10.155 W145 39.524
56	35	2	29	573	81603	C	N63 10.524 W145 40.164	61	50	2	30	576	81603	1.40	4	N63 11.307 W145 38.429
56	35	2	29	642	81604	C	N63 10.524 W145 40.164	27	15	9	20	627	81604	1.40	2	N63 09.657 W145 41.818
13	36	3	30	596	81610	C	N63 10.479 W145 39.898	23	43	4	21	608	81610	0.60	4	N63 10.559 W145 38.692
13	36	3	30	454	81611	C	N63 10.479 W145 39.898	85	29	6	29	457	81611	0.60	2	N63 10.245 W145 40.912
49	36	5	59	624	81612	D	N63 10.343 W145 39.587	34	36	1	30	630	81612	0.30	3	N63 10.512 W145 40.104
Recaptured same event					81612	C	N63 10.512 W145 40.104	20	38	1	26	627	81612	0.20	3	N63 10.579 W145 39.792
121	36	6	58	508	81625	D	N63 10.304 W145 39.475	21	41	2	68	517	81625	0.70	3	N63 10.932 W145 39.404
10	37	3	54	566	81640	C	N63 10.470 W145 39.618	37	34	2	46	574	81640	0.40	3	N63 10.445 W145 40.383
62	37	2	48	544	81648	C	N63 10.495 W145 39.683	86	37	5	24	554	81648	0.30	4	N63 10.289 W145 39.365
19	37	1	26	652	81651	C	N63 10.540 W145 39.777	14	37	1	24	656	81651	0.10	3	N63 10.576 W145 39.989
19	37	1	26	583	81654	C	N63 10.540 W145 39.777	61	50	2	30	583	81654	1.10	4	N63 11.307 W145 38.429
58	38	1	27	583	81656	C	N63 10.601 W145 39.711	34	36	1	30	587	81656	0.20	3	N63 10.512 W145 40.104
58	38	1	27	583	81658	C	N63 10.601 W145 39.711	330	13	4	26	567	81658	1.80	1	N63 09.675 W145 42.374
Recaptured same event					81658	A	N63 09.675 W145 42.374	12	34	4	45	574	81658	1.40	3	N63 10.338 W145 40.128
26	38	5	45	645	81662	D	N63 10.385 W145 39.315	49	1	1	2	645	81662	2.80	1	N63 09.405 W145 44.059
18	39	3	58	581	81664	D	N63 10.464 W145 39.316	81	13	3	28	580	81664	1.90	1	N63 09.737 W145 42.452
24	40	4	54	491	81673	D	N63 10.436 W145 39.175	87	18	2	6	490	81673	2.30	2	N63 09.421 W145 41.908
330	52	5	58	650	81692	D	N63 11.200 W145 38.362	137	50	4	55	653	81692	0.04	4	N63 11.168 W145 38.322
28	52	4	60	492	81701	D	N63 11.238 W145 38.460	120	44	2	51	491	81701	0.70	4	N63 10.653 W145 38.730
106	50	1	21	633	81749	C	N63 11.227 W145 39.119	101	35	4	46	631	81749	1.10	3	N63 10.402 W145 40.045
													average	1.01		

APPENDIX C: ADDITIONAL DATA

Appendix C1.–Growth of burbot sampled in Fielding Lake during 2008 bearing tags from previous studies.

Tag #	Color	Date	Length (mm TL)	Date last captured	Length (mm TL)	Years between capture	Total growth (mm)	Average growth mm/year
4330	5	6/16/2008	705	6/22/2000	588	8	117	15
4479	5	9/9/2008	820	6/21/2000	635	8	185	23
4755	5	6/18/2008	716	6/16/1999	420	9	296	33
4810	5	6/18/2008	763	6/17/1999	532	9	231	26
4915	5	6/17/2008	692	6/18/1999	403	9	289	32
4949	5	6/16/2008	826	6/19/1999	405	9	421	47
21759	6	6/17/2008	627	6/20/2000	446	8	181	23
21812	6	6/18/2008	730	6/21/2000	494	8	236	30
21841	6	9/10/2008	577	6/21/2000	437	8	140	18
21909	6	6/18/2008	835	6/22/2000	556	8	279	35
21934	6	6/19/2008	574	6/23/2000	483	8	91	11
21962	6	6/19/2008	610	6/23/2000	340	8	270	34
21999	6	6/19/2008	748	6/23/2000	555	8	193	24
						Average	225	27

Appendix C2.–Sex, age, length, weight, and maturity data collected from burbot killed during sampling at Fielding Lake, 2008.

Order	Date	Length (mm TL)	Tag number	Age	Sex	Maturity
1	6/17/2008	660	81506	…	F	…
2	6/18/2008	445	81552	5	M	immature
3	6/18/2008	630	81557	8	F	mature
4	6/18/2008	500	81572	4	F	mature
5	6/18/2008	562	81574	7	F	mature
6	6/18/2008	385	81579	5	M	immature
7	6/18/2008	568	81602	8	M	immature
8	6/19/2008	471	81702	9	M	immature
9	6/19/2008	390	81703	5	M	mature

APPENDIX D: DATA FILES

Appendix D1.–Data files for all burbot sampled in Fielding Lake, 2008.

Data file	Description
2008 Fielding Lake Burbot Data and Analysis.xlsx	This Excel® file contains edited data files recorded on the mark-sense forms, analyses, tables and figures used for this report

Note: Data files are archived at and are available from the Alaska Department of Fish and Game, Sport Fish Division, Research and Technical Services, 333 Raspberry Road, Anchorage, Alaska 99518-1599.